
Biotechnology and the manipulation of reproduction in humans and domestic animals

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 - synchronising breeding behaviour in sheep
 - increasing milk production
- ▼ The moral and ethical issues associated with using biotechnology to manipulate reproduction

REPRODUCTION and its HORMONAL CONTROL MANIPULATION and CONTROL of REPRODUCTION

Introduction

In both male and female mammals all aspects of sexual reproduction, including gamete production and mating behaviour, is under hormonal control. In both sexes interactions occur between reproductive hormones produced by the pituitary gland under the brain, and those produced within gonads (ovary and testes) which function to ensure optimum fertility. Understanding these interactions, particularly within the female, has provided many opportunities for human intervention in the process of reproduction.

Sexual cycles in the female mammal

In the sexually mature female mammal regular sexual cycles occur, during which one or more female gametes (ova, singular ovum) develop inside follicles and are released from the ovary, offering the chance of fertilisation if mating occurs. The general term for such cycles is the oestrus cycle. Oestrus cycles really consist of two closely linked cycles which are synchronised by hormonal interactions. These are:

- ▼ the **ovarian** or follicular cycle in the ovary which is concerned with the development and release of ova.
- ▼ the **uterine** cycle which is concerned with the development of the endometrium (uterus lining) to ensure the highest chance of implantation of a fertilised ovum.

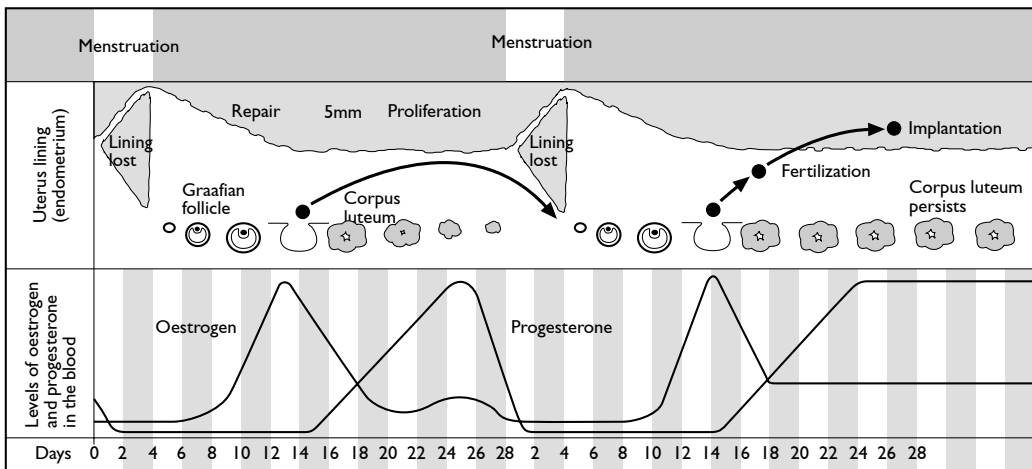
In the human female each cycle is approximately 28 days long. Ovulation which usually involves the release of a single ovum, occurs around the 14th day. The endometrium reaches a peak of thickness on day 21 and begins to break down on around day 28. This tissue, consisting of blood and cell debris is lost via the vagina during a menstrual period (menstruation). One cycle follows directly on from another throughout the year assuming that fertilisation does not take place.

Hormonal control of the oestrus cycle

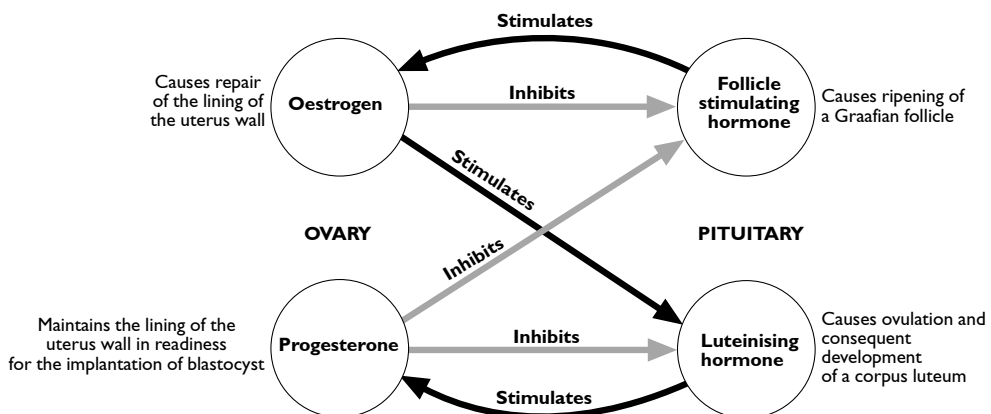
The sexual cycle relies on interactions between four main hormones: the ovarian hormones **oestrogen** and **progesterone** and the anterior pituitary hormones **Follicle Stimulating Hormone** (FSH), and **Luteinising Hormone** (LH). Although timings of the cycle vary between species the same basic pattern holds true. This can be summarised as follows.

- a) FSH is released from the anterior pituitary and travels in the bloodstream to the ovaries where it stimulates the development of several follicles (primary oocytes). One or more of these will eventually mature into an ovarian (Graafian follicle) containing the ovum (secondary oocyte)
- b) FSH stimulates the production of oestrogen from the follicles within the ovaries. This oestrogen in turn stimulates the proliferation of the uterus lining (endometrium), replacing cells lost during the previous menstrual period in humans (or, in the case of animals, those cells which were broken down and absorbed). At this point oestrogen inhibits the secretion of FSH (negative feedback control).
- c) Oestrogen levels increase until the mid point of the cycle when they bring about a peak of LH production from the anterior pituitary causing ovulation (the release of the ovum (pleural ova) secondary oocytes from Graafian follicles). A small peak of FSH production also occurs at the time of ovulation.
- d) LH causes the empty Graafian follicle to develop into a corpus luteum which begins to secrete progesterone and oestrogen.
- e) Progesterone stimulates further development of the endometrium, in particular an increase in the density of blood vessels and the secretion of mucus and fluid from glands in the lining. This is sometimes known as the secretory phase and its function is to prepare the uterus in case the newly released ovum is fertilised.

- f) The other function of progesterone is to inhibit the production of both FSH and LH and hence the development of further follicles.
- g) If fertilisation does not occur the corpus luteum degenerates and secretion of progesterone and oestrogen falls. This fall causes the uterus lining and some of its blood vessels to break down. In humans this is lost during menstruation, whilst in other mammals it is reabsorbed. Decline in progesterone levels causes the inhibition of FSH and LH to be removed and a new cycle can begin.
- h) If fertilisation does occur then the corpus luteum does not degenerate but continues to secrete progesterone and oestrogen, maintaining the uterus lining and preventing further follicles from developing. After about 12 weeks of pregnancy in humans and corresponding times in other mammals the developing placenta takes over the secretion of progesterone and oestrogen.



Oestrus cycle



Timing of sexual cycles

The length and details of the oestrus cycle varies amongst other mammals. Cycles may be as short as 4-5 days in the rat, extending to 21 days in the cow. In many wild animals, such as deer, only one cycle occurs per year which is associated with a particular breeding season probably triggered by environmental factors including changes in day length (photoperiod). Other animals with distinct breeding seasons such as the sheep may have several cycles within a given season whilst some such as cows and pigs resemble humans in having continuous cycles. This is known as being polyoestrus. Many large mammals (cow, horse) resemble humans in the release of a single ovum per cycle, whilst others such as the cat and rat may release as many as ten.

Oestrus and its significance

Oestrus is a change in the behaviour or appearance of a female mammal which occurs around the time of ovulation, indicating sexual receptiveness to males. It may involve the secretion of chemicals known as pheromones, swelling or change in colouration of the genital region or distinctive behavioural patterns, as discussed below. The human sexual cycle shows several unusual features which distinguishes it from the cycles of other mammals. Chief amongst these is the absence of oestrus, humans have the unusual feature of being sexually receptive at all times, regardless of the phase of the cycle.

In farm animals, such as cows, pigs and sheep, the presence of particular signs of oestrus which are detectable by humans, allows intervention in the process of reproduction. This is of great significance in modern farming where efficient breeding programmes are needed to allow the farm to exist as a profit-making business.

For a variety of reasons, including economic and safety reasons, many farms do not own male animals such as bulls, rams, stallions, or boars. Instead they may pay for the services of a male belonging to another individual, or, increasingly commonly, they may buy in semen with which to artificially inseminate the female animals. The use of semen (which is collected and stored in carefully controlled conditions to ensure high sperm quality and absence of sexually transmitted diseases) has many advantages over the use of natural breeding with a male animal. One of the most significant advantage is the ability to select and obtain semen from a male animal whose offspring are known to have specific desirable qualities such as high milk yield and quality, high meat quality, attractive appearance, and docility.

If artificial insemination (A.I.) or indeed mating, is to be used effectively then a farmer must be sure that the female animal is in oestrus before it is attempted. Insemination at other times will not result in pregnancy.

Signs characterising oestrus in the cow, pig and sheep are listed below. Careful observation by farmers, often several times per day, is necessary to spot these signs. Individual animals differ in the extent to which signs of oestrus are shown: some will show no signs, whilst others will show some or all of the signs.

The Cow

- ▼ Cows attempting to mount other females and then standing still and allowing themselves to be mounted by other females is the best sign of oestrus. On farms this may be detected in the following way: a type of paint is applied to the top part of the tail which will be rubbed off if the cow is mounted by another cow.
- ▼ Increased excitability. The cow shows a restless pattern of behaviour with increased time spent walking around and grooming other cows and decreased time resting.
- ▼ The cow may make a bellowing noise.
- ▼ A swollen vulva

NB. A bull may detect oestrus by sniffing the genital region of the cow (he detects chemical signals). In response to this he will show a lip curling response known as the 'flehmen response'.

The pig (sow)

- ▼ The most reliable sign of oestrus is the demonstration of the 'standing reflex' when pressure is applied to the lower back of the sow by the farmer. This is a rigid posture with the back legs extended that a female would adopt during mating. It occurs most frequently when pressure is applied to the back in the presence of a boar or when the female can detect the sound or scent of a boar. Synthetic 'boar odour' aerosols and tapes of boar sounds can be used instead of a real boar.
- ▼ A red swollen vulva and production of clear mucus from the vagina
- ▼ Sniffing of the genitals of other pigs and making a roaring or grunting noise may also occur.

The Sheep (Ewe)

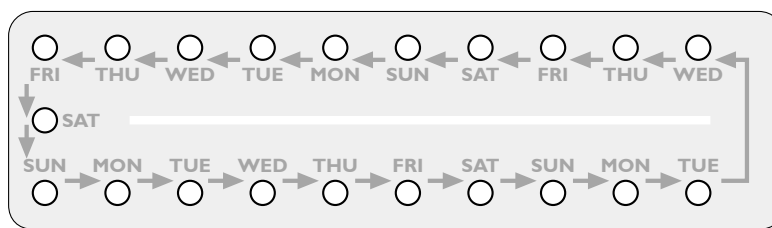
Detection of oestrus in the ewe is difficult since the sheep will only show signs if a ram is present. A farmer must therefore place a ram in with the sheep and watch the behaviour of both ram and ewes carefully. This ram may be a castrated animal and not therefore the male to be used for mating purposes. Under these circumstances oestrus is signalled by:

- ▼ Ewe standing firm and looking backwards, sometimes 'fanning' her tail (moving tail rapidly from side to side).
- ▼ Ram sniffing the genital region of the ewe, (suggesting the presence of chemical signals), curling his lip (flehmen response), pawing the ground and emitting a low pitched gurgling sound.

The control of reproduction: fertility and infertility.

The past century has seen a dramatic decline in the fertility of populations in most parts of the developed world and more recently within many developing countries. Fertility, in population terms, refers to the number of live births per 100 000 people and reflects the fertility of individual couples within that population. In Britain today each couple has, on average, 2 children compared to 6 or 7 a century ago. The main reasons for this is are an increase in the availability of contraception, associated with improvements in health (high chance of children surviving), education, and income.

Contraception can be defined as the prevention of conception (fusion of male and female gametes). Of the contraceptive techniques available to limit fertility, the most effective apart from abstinence or sterilisation, and most widely used, is the contraceptive pill (often called simply 'the pill'). First produced in 1951, and used but modified since that date, it works by interfering with the natural menstrual cycle of the human female and preventing ovulation. If used correctly it is over 99% effective in preventing pregnancy.



The most frequently used type of pill is known as the **combined contraceptive pill** which contains low doses of both of the steroid hormones oestrogen and progesterone in synthetic form. The effect of the pill is to prevent release of both LH and FSH via the negative feedback inhibition by oestrogen and progesterone. Without these hormones follicles do not develop in the ovary each month and are thus an ovum is not released. To achieve this effect the pill must be taken daily for 21 days in each 28 day cycle. In the 7 pill-free days which follow, the uterus lining breaks down in response to the withdrawal of progesterone, giving a type of light menstrual period. (In biological terms this is not strictly necessary but is built into the design of the contraceptive pill so that a semblance of normal cycles is achieved).

The contraceptive pill also exerts effects on other parts of the reproductive tract. Firstly it causes the mucus in the cervix region to thicken, making it more difficult for sperm to enter, and secondly it limits the thickness of the endometrium, making it more difficult for implantation of a fertilised ovum. If a progesterone only pill, the 'mini pill' is taken the effects are limited to these changes, inhibition of ovulation does not necessarily occur.

The development of other types of contraception based on hormones is continuing. One method which is already in use involves implanting tubes containing progesterone crystals under the skin which will release a constant low level of the hormone sufficient to reduce fertility. These may last for up to 5 years and have the advantage over the pill in that they do not need to be taken daily.

Treating infertility

Infertility, the inability to achieve pregnancy, easily or at all, is a growing problem in the developed world. Up to 1 in 8 couples in the UK may be affected. The causes are varied and can be associated with either the male partner, the female partner, or both. Causes include the long term consequences of some sexually transmitted diseases, genetic factors, physiological factors (including hormonal imbalance), psychological factors, environmental factors (exposure to some pollutants or to radiation), and increasing age of women trying to conceive. Whatever its cause infertility is a serious and distressing problem for many couples and it should be noted that whilst medical technology is improving the options for such couples, many of the treatments are lengthy, expensive and have low success rates. There are also a range of ethical and moral issues associated with some forms of infertility treatment which are discussed later.

In about 20 % of women who fail to conceive the underlying causes are hormonal. Hormonal imbalances can prevent the development of follicles or prevent the release of ova. In both cases treatment using synthetic or naturally occurring female hormones is highly successful in restoring fertility. A range of treatments is available most being based around stimulating the release of either FSH, LH or both. The first approach is to use a cheap synthetic anti-oestrogen drug called Clomiphene to stimulate the production of FSH and LH. If this is unsuccessful, FSH and LH themselves, may also be taken to stimulate the cycle at appropriate points. This treatment is more expensive since these hormones must be purified from the urine of post-menopausal women or produced by recombinant micro-organisms.

Where other infertility problems exist (including blocked oviducts in a woman and low sperm count of the male partner) treatment relies on various types of in vitro fertilisation (IVF). IVF involves the extracting of both ova and sperm from the body, encouraging fertilisation outside the body, and then transferring any resultant zygotes back into the uterus of a woman (who may or may not be the donor of the ova). In order to extract large numbers of ova to allow for several attempts at IVF, both FSH and LH are commonly used to encourage multiple ovulation.

A further use of female hormones is in hormone replacement therapy (HRT) used to treat some of the unpleasant symptoms of the menopause in older women. In such women, synthetic oestrogens are given to make up for the decline in natural production which occurs as the menstrual cycle stops. This has many benefits: it reduces some of the physiological and psychological changes that often occur at the menopause.

◆ CHECKPOINT SUMMARY

- ◆ Contraception can be defined as the prevention of conception (fusion of male and female gametes). The most widely used is the contraceptive pill
- ◆ The 'pill' works by interfering with the natural menstrual cycle of the human female and preventing ovulation
- ◆ The commonest used type of pill is the combined contraceptive pill which contains low doses of hormones oestrogen and progesterone in synthetic form
- ◆ The effect of the pill is to prevent release of both LH and FSH via the negative feedback inhibition by oestrogen and progesterone
- ◆ To achieve this effect the pill must be taken daily for 21 days in each 28 day cycle. In the 7 pill-free days which follow the uterus lining breaks down in response to the withdrawal of progesterone, giving a type of light menstrual period
- ◆ The contraceptive pill also exerts effects on other parts of the reproductive tract. Firstly it causes the mucus in the cervix region to thicken, making it more difficult for sperm to enter; and secondly it limits the thickness of the endometrium, making it more difficult for implantation of a fertilised ovum
- ◆ If a progesterone only pill, the 'mini pill' is taken the effects are limited to these changes: inhibition of ovulation does not necessarily occur
- ◆ The development of other types of contraception based on use of hormones are being investigated. One method which is already in use involves implanting tubes containing progesterone crystals under the skin which will release a constant low level of the hormone sufficient to reduce fertility
- ◆ In about 20 % of women who fail to conceive the underlying causes are hormonal. Treatment using synthetic or naturally occurring female hormones is highly successful in restoring fertility
- ◆ A range of treatments for infertility in the female are available based around stimulating the release of either FSH, LH or both
- ◆ Both FSH and LH are commonly used to encourage multiple ovulation for in vitro ('test tube') fertilisation.

HORMONES in DOMESTIC ANIMALS

Superovulation and embryo transfer

As discussed above, artificial insemination gives farmers the ability to select semen from male animals showing particular desirable characteristics, so improving the quality of his stock. Recently technology has become available to allow selection of breeding females in a similar, although slightly more limited way. This procedure involves manipulating the reproductive biology of females (usually cows) by superovulation and embryo transfer and involves the following stages:

- ▼ Cattle, or other farm animals are treated with hormone injections to stimulate the development and release of much larger numbers of ova than would naturally occur. As in humans, the main strategy involves using FSH and LH at appropriate times. Theoretically up to 50 ova may be released per cycle, but generally it is between 3 and 8.
- ▼ When ovulation occurs (detected by the signs of oestrus mentioned above, or by calculation of time since LH injection) the cow is artificially inseminated.
- ▼ The fertilised ova are allowed to develop for up to 7 days and are then washed out of the uterus before implantation occurs.
- ▼ The embryos are frozen and stored until required.
- ▼ Embryos are then introduced into the uterus of cows other than those from which they were obtained; they implant and develop until full term. This process is known as **embryo transfer**. It should be noted that whilst embryos may be implanted in females from the same farm they may also be sold for implantation in cows in different regions or countries.

By this process a single high quality cow may produce a very large number of offspring allowing the quality of a herd to improve very quickly. Estimates from the 1980s show that superovulation of a cow is possible every 2-3 months. Each time 6-7 normal embryos will result from artificial insemination, of which 3-4 will successfully develop into calves. This gives a total of 15-18 calves per donor female per year. As these calves grow up their qualities in terms of meat and milk production can be assessed allowing farmers to rapidly ascertain the best cattle to breed from.

There are variants on the type of embryo transfer described above and the reasons for performing it. One main aim is to use embryo transfer to establish twin pregnancies in cattle where twinning is uncommon. This can potentially double productivity. Twin pregnancies are most often obtained by transferring two embryos into a cow who has not been inseminated, although they may be added to an existing zygote in the uterus of a cow who has already been inseminated. In some cases the sex of embryos may be determined before transfer. This is valuable to farmers as it ensures that they can achieve desired ratios of male to female cattle (more males than females required for beef farming and vice versa for dairy). The embryos may also be split to produce clones (genetically identical individuals) before transfer.

Synchronisation of oestrus

The synchronisation of oestrus cycles in flocks of sheep (ewes) or herds of cows is a very desirable way of manipulating animal reproduction. The aim of this process is to ensure that all animals in the herd come into oestrus on approximately the same day and can be mated or artificially inseminated at the same time. This allows substantial savings for the farmer in terms of both time and money, as well as improving conception rates and ensuring that the entire flock will be producing offspring at the same time the following season. Synchronised oestrus is particularly desirable in ewes, as opposed to cows or sows for two reasons: firstly these animals have distinct breeding seasons and cannot become pregnant outside of this season and secondly, many flocks of sheep live in isolated hill regions. It is much more efficient to herd the sheep together to start treatment and then again for mating or A.I.

The process of synchronisation is based on the administration and then withdrawal of the female hormone progesterone. Progesterone inhibits FSH and LH secretion and hence prevents the development of follicles and the release of ova. The process is as follows:

- ▼ All ewes in a flock are treated with progesterone for 5-9 days. The hormone is administered in one of three ways: orally, via an implant under the skin, or via a sponge in the vagina.
- ▼ The progesterone is stopped in all ewes on the same day. This removes the inhibition of FSH and LH and allows follicles to start development in the ovaries of the ewes.
- ▼ Several days later the ewes come into oestrus.
- ▼ A ram is obtained and used to fertilise all the sheep at the same time. Alternatively A.I. may be used. This may ensure higher fertilisation rates, be quicker, prevent the spread of disease and allow semen to be chosen from a wide range of rams.
- ▼ All ewes who were fertilised produce lambs at approximately the same time.

In addition to its use in synchronising oestrus during the breeding season, the use of hormonal treatments has also allowed flocks of ewes to come into oestrus (synchronised) at other times of the year. In these cases progesterone is given as described above but an extra hormone, gonadotrophin, is required to stimulate FSH and LH secretion. Light stimulation is sometimes used as well since the breeding season is triggered by changes in light intensity. Such manipulation may be used to shift the timing of oestrus and hence of lambing to more suitable times of the year based on known or predicted environmental or economic conditions. In some cases, where environmental conditions permit, farmers may divide their flocks into two, having half mating in October and lambing in March and the rest mating in July and lambing in December.

Milk production in cows

Over the thousands of years of animal husbandry, cows have been selectively bred to give high milk yields. Traditional breeding techniques combined with the modern use of A.I. and embryo transfer and improved understanding of bovine (cow) nutrition and management has led to enormous increases in yield in domestic breeds compared to wild cattle. Even though a high yielding cow may produce over 40 litres of

milk per day (up to 12,000 litres/year) there is still an interest in further boosting production. One reason for this is that in many countries (including Britain), prices paid to farmers for milk are very low, forcing farmers to maximise productivity if they are to make a profit. One solution to this is to boost production using hormones.

The hormone BST, (bovine somatotrophin), is a pituitary growth hormone which occurs naturally in young cattle. Its function is to increase cell division, protein synthesis and growth. Trials with BST, which is now produced by genetically engineered bacteria, showed that injecting dairy cows with the hormone led to a 10-15% increase in milk yield, presumably through an increase in growth and activity of milk producing tissue in the udder. Some of the advantage was offset by the fact that cows injected with BST require more food, but a net profit still resulted. These early trials showed no apparent change in behaviour, health or reproductive capacity of the cows.

Although BST is approved for use in cows in the USA, the hormone is banned in the European Union. This decision followed public protest as well as further scientific investigations of cows treated with BST which did suggest some health problems, including reduced resistance to disease.

Moral and Ethical Issues associated with interventions in reproduction

Any intervention in the process of reproduction is likely to be considered unethical by some groups in society. One widely held view is that increased availability of contraceptives, and particularly of the contraceptive pill, encourages sexual promiscuity. In addition, some religions, including Roman Catholicism and Islam condemn the use of contraceptives of any kind, arguing that limiting procreation is against God's will. Such religions do indeed value large families, and in many parts of the world the large family does provide an effective support system for elderly people. In opposition, however, many other groups would point to the benefits to both individuals and societies that contraceptive technology has brought. In dramatically decreasing birth rates it has improved the physical and emotional well-being of women across the world. In limiting family size it has also helped to contribute towards improvements in child health and economic status in many regions.

Intervention in human reproduction to treat infertility (mainly that involving IVF) is also the subject of much debate. Although the number of people undergoing such treatments is very small compared to the numbers using contraception, the issues raised concern society as a whole. Increasingly issues concerning the rights of individuals to have children are becoming high profile legal cases, emphasising the fact that medical and scientific advances in this field must be matched by progress in the fields of ethics and law.

A major argument exists over the fate of spare embryos (or pre-embryos) that have been conceived by IVF. There is a case for using them in medical research; particularly research associated with improving understanding of infertility and the development of new techniques to treat it. Others, however, believe that embryos are new individuals and that this would be immoral or unethical. As with discussions surrounding abortion one of the issues here concerns the right to life and the ownership of the embryos.

Making Use of Biology

Biotechnology and the manipulation of reproduction in humans and domestic animals

Reproduction and its hormonal control

Topic Guide

Session:

Check List

- ▼ In the sexually mature female mammal regular sexual cycles occur, during which one or more female gametes (ova, singular ovum) develop inside follicles and are released from the ovary, offering the chance of fertilisation if mating occurs
- ▼ These cycles really consist of two closely linked cycles which are synchronised by hormonal interactions.
- ▼ The follicular or ovarian cycle which is concerned with the development and release of ova.
- ▼ The uterine cycle which is concerned with the development of the endometrium (uterus lining) to ensure the highest chance of implantation of a fertilised ovum or zygote.
- ▼ The sexual cycle relies on interactions between four main hormones: the ovarian hormones oestrogen and progesterone, and the pituitary hormones Follicle Stimulating Hormone (FSH), and Luteinising hormone (LH). Although timings of cycle vary between species the same basic pattern holds true.
- ▼ FSH is released from the anterior pituitary and stimulates the development of several follicles (primary oocytes) in the ovary. One or more of these will eventually mature into a Graafian follicle containing the ovum
- ▼ FSH stimulates the production of oestrogen from the follicles within the ovaries. This Oestrogen in turn stimulates the proliferation of the endometrium. At this point oestrogen inhibits FSH (negative feedback control).
- ▼ Oestrogen levels increase until the mid point of the cycle when they bring about a peak of LH production from the anterior pituitary causing ovulation (the release of the ova from Graafian Follicles).
- ▼ LH causes the Graafian Follicle to develop into a corpus luteum which begins to secrete the progesterone and oestrogen.
- ▼ Progesterone stimulates further development of the endometrium to prepare the uterus in case the newly released ovum is fertilised.
- ▼ The other function of progesterone is to inhibit the production of both FSH and LH and hence the development of further follicles.
- ▼ If fertilisation does not occur the corpus luteum degenerates and secretion of progesterone and oestrogen falls. This fall causes the uterine blood vessels to rupture and the uterus lining to degenerate. Decline in progesterone levels causes the inhibition of FSH and LH to be removed and a new cycle can begin.
- ▼ If fertilisation does occur then the corpus luteum does not degenerate but continues to secrete oestrogen and progesterone, maintaining the uterus lining and preventing further follicles from developing. Eventually the developing placenta takes over this endocrine role.
- ▼ Oestrus is a change in the behaviour or appearance of a female mammal which occurs around the time of ovulation, indicating sexual receptiveness to males.
- ▼ Cows attempting to mount other females and then standing still and allowing themselves to be mounted by other females is the best sign of oestrus.
- ▼ Detection of oestrus by humans, allows intervention in the process of reproduction, e.g. by artificial insemination (AI).

Student Activity

Materials

- Microscopes and slides of TS mammalian ovary
- OHT ovarian cycle in human female

Procedure

Make a series of sketches illustrating the different stages of follicle development in the ovarian cycle.

Set Work

List the advantages of artificial insemination over 'natural' fertilisation.

Making Use of Biology

Biotechnology and the manipulation of reproduction in humans and domestic animals

Manipulation and control of reproduction

Topic Guide

Session:

KEY SKILLS

Check List

- ▼ Contraception can be defined as the prevention of conception (fusion of male and female gametes). The most widely used is the contraceptive pill (often called simply 'the pill').
- ▼ The 'pill' works by interfering with the natural menstrual cycle of the human female and preventing ovulation. If used correctly it is over 99% effective in preventing pregnancy.
- ▼ The most frequently used type of pill is known as the combined contraceptive pill which contains low doses of both of the steroid hormones oestrogen and progesterone in synthetic form.
- ▼ The effect of the pill is to prevent release of both LH and FSH via the negative feedback inhibition by oestrogen and progesterone.
- ▼ To achieve this effect the pill must be taken daily for 21 days in each 28 day cycle. In the 7 pill-free days which follow the uterus lining breaks down in response to the withdrawal of progesterone, giving a type of light menstrual period.
- ▼ The contraceptive pill also exerts effects on other parts of the reproductive tract. Firstly it causes the mucus in the cervix region to thicken, making it more difficult for sperm to enter, and secondly it limits the thickness of the endometrium, making it more difficult for implantation of a fertilised ovum.
- ▼ If a progesterone only pill, the 'mini pill' is taken the effects are limited to these changes: inhibition of ovulation does not necessarily occur.
- ▼ The development of other types of contraception based on use of hormones are being investigated. One method which is already in use involves implanting tubes containing progesterone crystals under the skin which will release a constant low level of the hormone sufficient to reduce fertility. These may last for up to 5 years and have the advantage over the pill in that they do not need to be remembered daily.
- ▼ In about 20 % of women who fail to conceive the underlying causes are hormonal. Hormonal imbalances can prevent the development of follicles or prevent the release of ova. In both cases treatment using synthetic or naturally occurring female hormones is highly successful in restoring fertility.
- ▼ A range of treatments for infertility in the female are available based around stimulating the release of either FSH, LH or both.
- ▼ Both FSH and LH are commonly used to encourage multiple ovulation for in vitro ('test tube') fertilisation.

Student Activity

Materials

□ OHT Ovarian cycle

Procedure

Use □ OHT Ovarian cycle as a basis for understanding contraception by use of the pill.

Debate the moral and ethical issues associated with the use of the contraceptive pill.

Set Work

List the moral and ethical issues associated with the use of the contraceptive pill.

Notes:

Making Use of Biology

Biotechnology and the manipulation of reproduction in humans and domestic animals

Reproduction and its hormonal control

Topic Guide

Session:

KEY SKILLS C3 all

Check List

- ▼ Cows are treated with hormone injections to stimulate the development and release of much larger numbers of ova than would naturally occur. As in humans, the main strategy involves using FSH and LH at appropriate times. In other cases a gonadotrophin hormone is used.
- ▼ When ovulation occurs (detected by the signs of oestrus mentioned before, or by calculation of time since LH injection) the cow is artificially inseminated.
- ▼ The fertilised ova are allowed to develop for up to 7 days and are then washed out of the uterus before implantation occurs.
- ▼ The embryos are frozen and stored until required.
- ▼ Embryos are introduced into the uterus of cows other than that from which they were obtained, where they implant and develop until full term. This process is known as 'embryo transfer'.
- ▼ By this process a single high quality cow may produce a very large number of offspring allowing the quality of a herd to improve very quickly.
- ▼ The synchronisation of oestrus cycles in flocks of sheep (ewes) or herds of cows ensures that all animals in the herd come into oestrus on approximately the same day and can be mated or artificially inseminated at the same time.
- ▼ Synchronised oestrus is particularly desirable in ewes, as opposed to cows or sows for two reasons: firstly these animals have distinct breeding seasons and cannot become pregnant outside of this season and secondly, many flocks of sheep live in isolated hill regions. It is much more efficient to herd the sheep together to start treatment and then again for mating or A.I.
- ▼ All ewes in a flock are treated with progesterone for 5-9 days. The hormone is administered in one of three ways: orally, via an implant under the skin, or via a sponge in the vagina.
- ▼ The progesterone is stopped in all ewes on the same day. This removes the inhibition of FSH and LH and allows follicles to start development in the ovaries of the ewes.
- ▼ Several days later the ewes come into oestrus.
- ▼ A ram is obtained and used to fertilise all the sheep at the same time. Alternatively A.I. may be used. This may ensure higher fertilisation rates, be quicker, prevent the spread of disease and allow semen to be chosen from a wide range of rams.
- ▼ All ewes who were fertilised produce lambs at approximately the same time.
- ▼ Even though a high yielding cow may produce over 40 litres of milk per day (up to 12 000 litres/year) there is still an interest in further boosting production.
- ▼ The hormone BST, (bovine somatotrophin), is a pituitary growth hormone which occurs naturally in young cattle. Its function is to increase cell division, protein synthesis and growth. Trials with BST, which is now produced by genetically engineered bacteria, showed that injecting dairy cows with the hormone led to a 10-15% increase in milk yield, presumably through an increase in growth and activity of milk producing tissue in the udder.

Student Activity

Procedure

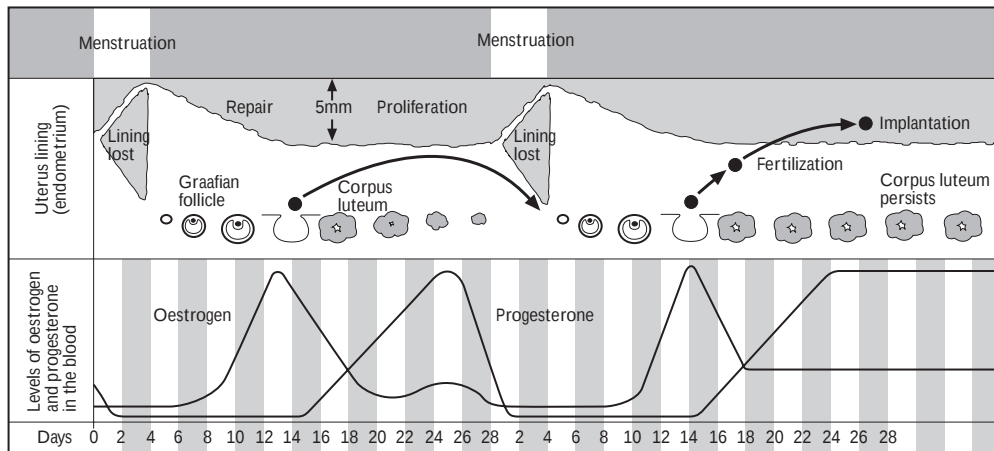
Debate the moral and ethical issues associated with using biotechnology to manipulate reproduction in animals.

Set Work

List the moral and ethical issues associated with using biotechnology to manipulate reproduction in animals.

Question 1

Study the diagram below of the ovarian (menstrual) cycle in the human female and answer the following questions.



- a) i) What event in the ovary coincides with the peak of oestrogen levels in the blood?

(1)

- ii) What event results in the maintenance of high levels of progesterone in the blood?

(1)

- b) Describe how contraceptive pills act to control human fertility.

(6)

Total 8

Question2

The manipulation and control of reproduction in domestic animals is of great commercial interest. One example is seen in the use of Bovine somatotrophin (BST) otherwise known as bovine growth hormone. When BST is injected into dairy cows their milk yield increases by up to 20%

- a) i)** Describe how the hormone could affect the animal's metabolism to produce the increase in milk yield.

(3)

- ii) Given a constant demand for milk, suggest the effect that the use of BST will have on dairy herds.

(1)

- iii) Describe an important aspect of milk as a product, in addition to that of yield.

(1)

- b)** Give a short account of the criticisms that could be made against the use of BST in dairy cows.

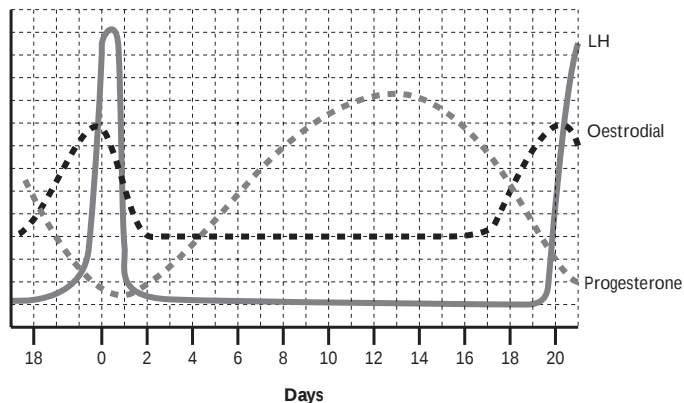
This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(6)

Total 11

Question 3

The oestrous cycle of dairy cows is shown below.



- a) i) From the diagram above determine the length of the oestrus cycle.

(1)

- ii) Give a brief description of the variations in the levels of luteinising hormone (LH) during this cycle.

(2)

- iii) On the diagram indicate the time of ovulation in this cycle.

(1)

- b) Explain why the detection of oestrus, or the period of 'heat', in dairy cows is of commercial significance.

(6)

Total 10